Financial Networks

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Computational Management Science 10 (2013) pp 77-80

This special issue on *Financial Networks* consists of a selected collection of eight state-of-the-art papers advancing the frontiers of financial network modeling, analysis, and computations from both theoretical and empirical perspectives by authors from academia and financial services firms who responded to a call for papers in this journal. The growing resurgent interest in this topic is motivated, in part, by the recent global financial crisis, which has dramatically brought attention to financial systems with new challenges for analytical frameworks and methodologies.

The lead article utilizes graph theory, integrated with statistics, in a comprehensive computational study of the U.S. stock market over a recent decade. The second paper also considers the market graph and proposes a simple measure of similarity for its construction, which is then applied for an analysis of the Swedish and the Russian stock markets. The second two papers focus on financial contagion, with the first one providing a large-scale computational study on an extended interbank exposures network for the Mexican financial system and the second one introducing an approach to construct interbank networks when bilateral exposures are not available, along with an index for contagion. The next two papers yield further insights into financial network dynamics. The first one focuses on the Italian e-MID (electronic market for interbank deposits) based on overnight loans during the 1999-2010 period and computes various network measures at different levels of time aggregation.

The next paper develops a theoretical, dynamic, computable network formation model for banks' rollover decisions using game theory. The final two papers expand upon the financial networks theme through novel theoretical multitered models, which capture decision-makers' behavior, with the first paper analyzing the incorporation of socially responsible investing on profits, risk, and social responsibility levels, and the second paper capturing the co-evolution of supply chain networks with corporate financial networks and insolvency risk under varying economic factors. Both models in these final two papers utilize variational inequality theory for the formulation of the equilibria, their analysis, and subsequent computation.

Shirokikh, Pastukhov, Boginski, and Butenko, in the lead article, advance the study of the network-based model known as the market graph in which nodes/vertices represent stocks and two nodes are connected by an (undirected) link if the correlation between their corresponding price fluctuations over a certain time period exceeds a user-defined threshold. An attractive feature of the market graph modeling approach is that it can reflect and visually depict market trends via standard graph-theoretic parameters (edge density, distribution, etc.) with each instance of the market graph for a specific period providing a snapshot of the market. However, unlike the previous literature, which utilized the Pearson correlation criterion for creating links between stocks, the authors propose the use of the Spearman rank correlation. They also propose a preprocessing procedure for removing outliers in the data and then analyze the stock price fluctuations for the U.S. stock market from November 2001 to November 2011. Their computational study characterizes the decade-long evolution of the market, captures interesting trends, and reveals that although some of the "global" characteristics of the networks (such as the degree distribution and the power law parameter) exhibit stable and monotonic behavior, "local" characteristics associated with cohesive clusters and highest-degree nodes behave non-monotonically, especially during the most recent time periods, and may be due to significant events, such as crises.

Bautin, Kalyagin, Koldanov, Koldanov, and Pardalos continue the theme of the study of the stock market as a complex network with the goal of identifying new measures of similarity of random variables for stock market network construction. They note that although the classic Pearson correlation has been the most popular measure applied in the study of the stock market, its main disadvantage is weak robustness due to failures of assumptions of an identical distribution of the underlying random variables. The authors propose a simple

measure of similarity based on the probability of the coincidence of the signs of the stock returns. The advantages of the new measure include: robustness, an elegant interpretation, and ease of computation as well as the possibility of determining the degree of connections of any number of random variables. They then apply the new measure, along with the classic Pearson correlation one, for the study of the Russian and the Swedish stock market graphs. They also provide theoretical results on the new measure's properties in comparison to the classic one.

Solorzano-Margain, Martinez-Jaramillo, and Lopez-Gallo make use of network theory to characterize financial contagion in the context of stress testing and systemic risk, topics that have been studied by both academics and central banks. The authors focus on direct contagion, which refers to the failure of banks as a consequence of other banks not honoring their commitments and directly affecting the solvency of the other exposed banks; and macroeconomic stress testing. They test the fragility of the Mexican financial system using monthly information on exposures from July 2008 until December 2010 and daily information on exposures from January 2011 to August 2011. Their large-scale empirical study with no data gaps provides evidence of financial contagion with an extended interbank exposures network. This is the first study in which a large-scale BVAR (Bayesian Vector Autoregressive) model has been used to perform system-wide stress testing.

Halaj and Kok also focus on financial contagion and provide an approach to construct interbank networks when data on bilateral interbank exposures is not available. Their robust method makes use of individual banks' aggregate interbank exposures to simulate a wide range of possible interbank networks. A dynamic analysis of how and to what extent shocks to different entities propagate throughout the financial network system can then be conducted once the interbank connectedness structures are simulated. They also propose a "contagion index," called the Systemic Probability Index (SPI) that provides a robust proxy for simulated networks but is computationally less intensive. In addition, they create networks between large banks in the European Union, as a whole, whereas most studies refer to specific country settings. This allows the investigation of cross-border interbank contagion. Their simulations confirm that contagion is heterogeneous across the banking system and strongly nonlinear.

Finger, Frick, and Lux analyze the network properties of the Italian e-MID data based on overnight loans during the period 1999-2010. Such data can be purchased freely without any restrictions. The authors find, through the use of network statistics, that networks constructed from daily data feature a substantial amount of randomness as well as asymmetry. However, they contain non-random features over longer time aggregation periods. The authors suggest, hence, that inference based on high-frequency (daily) data may be misleading while a higher level of time aggregation might provide for a more complete view of the interbank market. They also find that the global financial crisis can be identified as a significant structural break for many network measures.

Fique and Page propose a dynamic network formation game theory model with borrowers and lenders and with three stages that they then solve numerically to study banks' rollover decisions. They find that, when the linkages between market participants generate an informational externality, the newly formed network is conditioned by past architectures. In addition, they note that this inertia is strongly dependent on macroeconomic conditions, such as the investors' risk appetite, and market frictions, with an example of frictions being the special bank levy that was implemented as part of vast regulatory reforms imposed following the recent global financial crisis. They recommend that, in order to restart lending after a major stress situation in the interbank market, a notable reduction in the special bank tax levy is needed, and advise a counter-cyclical policy similar to the ones proposed by the Basel Committee on Banking Supervision (BCBS) in 2010 with respect to capital requirements.

Qiang, Ke, and Hu develop the first multitiered financial network model, consisting of sources of funds (households, business, etc.), intermediaries (banks, insurance companies, etc.), and consumers at demand markets, that quantifies the social awareness of investing firms. Both sources and intermediaries are multicriteria decision-makers with the latter interested not only in profit maximization and risk minimization but also in maximizing the monetary value of the social responsibility levels of their investments. The authors capture the behavior of the decision-makers, and establish the variational nequality of the governing equilibrium conditions. In addition to the qualitative analysis of the equilibrium solutions, they illustrate, through numerical examples, the impacts of the weights imposed on the social responsibility criteria by the intermediaries as well as the selection of the minimum

social responsibility level of an intermediary on the financial flows and the financial product demands.

Liu addresses the impacts of corporate financial networks on supply chain networks in a a model that formulates the co-evolution over time of these two types of networks under varying economic conditions. The supply chain network consists of suppliers, manufacturers, and demand markets. In each time period, each supplier maximizes its profits, and minimizes the total credit risk of its transactions; the manufacturers also maximize their profits. His theoretical model formulates the supply chain network equilibrium problem as a variational inequality problem. Inputs into the supply chain network problem for each period include accounting and financial measures from the previous period. New accounting and financial measures are calculated for the financial network based on the supply chain network equilibrium solution. Qualitative analysis was conducted along with a computational study to investigate such network evolution under economic conditions similar to those in 2008-2009 where product demand declined and credit markets tightened up.

Acknowledgments I am grateful to the authors for submitting their work to this special issue on *Financial Networks*. I also acknowledge the hard work and diligence of the reviewers for their thorough, thoughtful reviews of the original manuscripts, whose suggestions significantly enhanced the quality of the final papers. Finally, I am indebted to the Editor-in-Chief, Professor Berç Rustem, for the opportunity to guest edit this special issue of *Computational Management Science*.